12p.

X 63-11413
code-2d

NASA TT F-8199

[redacted]

EFFECTS IN THE IONOSPHERE OBSERVED IN GOR'KIY DURING THE PERIODS OF SOLAR ECLIPSES ON 2 DECEMBER 1956 AND 15 FEBRUARY 1961

by V. A. Vasin and L. V. Grishkevich

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON March 1962

[redacted] DRAFT TRANSLATION NASA TT F-8199

MAR 26 1962

EFFECTS IN THE IONOSPHERE OBSERVED IN GOR'KIY DURING THE PERIODS OF SOLAR ECLIPSES ON 2 DEC. 1956 AND 15 FEB. 1961.

(Ob effektakh v ionosfere, nablyudavshikhsya v periody solnechnykh zatmeniy 2.XII 1956 g i 15. II 1961 g. v Gor'kom)

Geomantizm i Aeronomia
Tom I, No. 6, pp. 949-954,
Izd-vo A. N. SSSR, 1961

by V. A. Vasin
L. V. Grishkevich

ABSTRACT

Described are solar eclipse effects in the E and F_2-layers of the ionosphere observed in Gor'kiy on 2 December 1956 and 15 February 1961. Despite the fact that both eclipses occurred in winter, more or less at the same time, their influence on the ionosphere, and particularly on F_2-layer, was revealed by different methods. According to data of 2 December 1956, computed were the coefficients α_{eff} and J_o, the most probable values of which for the E-layer constituted $0.25 \cdot 10^{-8}$ cm^3 sec^{-1}, and 150 el $\cdot$ cm^{-3} sec^{-1}, and for the F_2-layer — $2 \cdot 10^{-10}$ cm^3 sec^{-1} and 2300 el $\cdot$ cm^{-3} sec^{-1} respectively.

COVER-TO-COVER TRANSLATION

Observations of the state of the ionosphere were conducted at the NIFRI station during solar eclipses of 2 December 1956 and 15 February 1961. In the first case, a hand-controlled ionosphere station was utilized, with a 2 kw power in the pulse of $\sim$50 sec with a 50 c/s cycle frequency. The operating frequency range of the station was 1.8 — 18 Mc/s. The transmitting and receiving antennas had a Δ - shape. In the second case, observations were carried out with the aid of an automatic type -AIS ion probe, the parameters of which are described in reference [2]. Presented are below the results of investigations of E and F_2 - layers' behavior during the eclipses' and monitoring days.

EFFECTS OF ECLIPSE IN THE E AND F-LAYERS OF THE IONOSPHERE ON 2 DEC.1956

Results of Check Observations. These were conducted in the ionosphere from 28 November to 4 December 1956. During that period, high-frequency characteristics were taken down daily, every 30 minutes between the hours 06 00 and 17 00 for the check days, and every 15 minute at the day of eclipse. The time indicated is the local 45° E time throughout. During the eclipse hours, the h'f characteristics were taken down uninterruptedly during 3 — 5 minutes each.

The analysis of the course of E and F_2 -layers' critical frequencies provided a basis for considering the state of the ionosphere during the check days as quiet. The variation of critical frequencies f_oE as a function of time of the day for each day of observations did not reveal any significant deflections from the course of median values for the check days. At the same time, the curve of median values f_oE during the period 8 00 — 16 00 hours, was described quite satisfactorily by the law $\cos \chi(t)$, where $\chi(t)$ is the Sun's zenithal angle.

It follows from the comparison of the daily critical frequencies' f_oF_2 course for the same days of observations, that their values also were basically controlled by the Sun's zenithal angle. However, small deflections in the f_oF_2 magnitude by comparison with the median values ($\Delta f_o F_2 \simeq \pm 0.3$ Mc/s) were observed during near midday hours, which are typical for the F_2 layer.

At the same time, during hours close to sunset, more significant fluctuations in f_oF2 magnitudes relatively to the curve characterizing the average trend of their variation in daylight, have taken place during the control days. That is why, median values of $f_o F2$ varied irregulrly during the same hours. (See Fig.1, at the top, taking note of the fact, that moments of eclipse at the Earth's surface are plotted on all graphs).

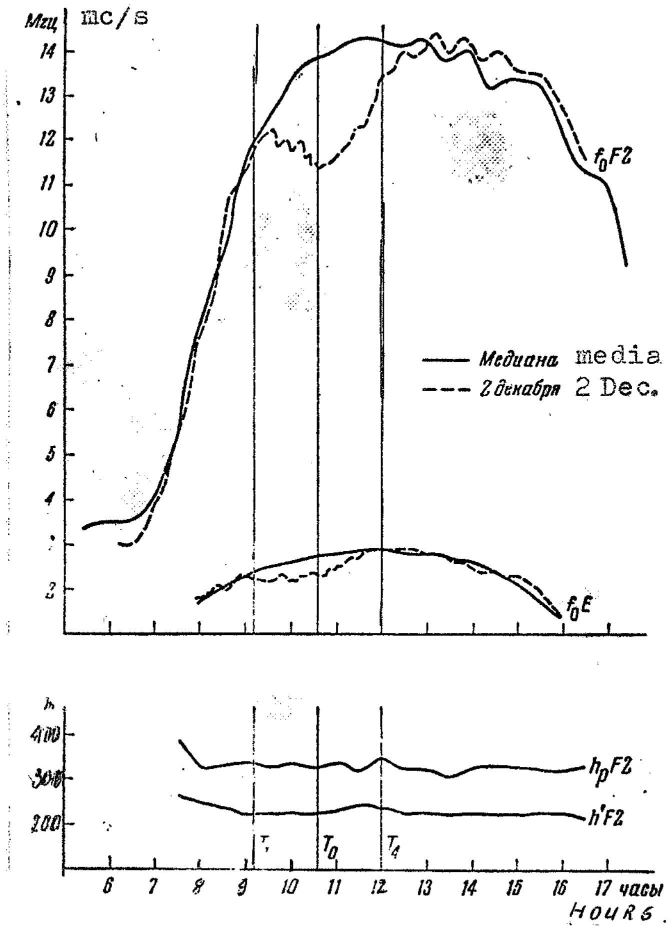

Fig.1

In order to clarify the degree of possible F_2-layer's deformation during eclipse time by comparison with control days, the magnitudes $h'F2$ and $h_p F2$ were computed with the aid of h'f characteristics, and their dependence on the time of the day — plotted in Fig.1.

It may be concluded that if the distribution of electron concentration N_e (h) in the F2 - layer is near parabolic, the configuration of the F_2-layer during daytime of the control and eclipse periods remained practically unchanged despite the above-noted irregularity of f_oF_2 variation in time. The type - C- E_s-layer was rather regularly observed during control observations, and reflections of l - type of E_s-layer took place at times. However, the critical frequencies of the E_s -layers' first type usually exceeded the values f_oE by more than 0.5 mc/s. During that time of the day, the type E_s-layer was insiffusiently intense to screen the normal E-layer.

Cases of Eclipse in E and F-layers. The solar eclipse of 2 December 1956 observed in Gor'kiy was partial, with a maximum phase of 0.73 at the Earth's surface. Data on optical darkening at different levels relatively to Earth's surface (T_1 and T_4 being the moments of the first and last contacts ; P_1 and P_4 — their respective angles ; T_o being the moment of the maximum phase and g_{max} — the maximum phase of eclipse). All the computations were made taking account [4] of altitudes h = 0, 100, 200 and 300 km.

h km	T_1	T_o	T_4	g_{max}	P_1^o	P_4^o
0	09 11	10 34	12 01	0.73	291	81
100	09 11	10 34	12 01	0.76	290	82.5
200	09 10	10 33	12 01	0.78	289	84
300	09 08	10 32	12 01	0.80	288	85.5

The comparison of h'f- characteristics, obtained during the eclipse period, with the corresponding characteristics related to control days revealed a sharply expressed decrease of critical frequencies f_oE and f_oF_2. As may be seen from Fig. 1, the particularities of electron concentration N_m variation at the maximum level of both layers was basically determined by the zenithal angle of the Sun and by the phase of optical eclipse. The moments of optimum decrease of magnitudes N_m of the E and F-layers practically coincide with the moments of the optimum phase of eclipse at the 100 - 300 km height level. The greatest relative lowering of the critical frequencies f_oE and f_oF_2 during eclipse time constituted in both cases about 18 percent by comparison with the corresponding median values.

It follows from Fig.1, that the effect of the eclipse was more clearly expressed in the F_2 than in the E-layer. This apparently may be explained by the fact, that the eclipse phenomenon itself took place during hours when the Sun's zenithal angle increased rapidly, which compensated its effect in the ionosphere. However, the notable decrease in critical frequencies f_oF_2 in comparison with the median immediately after the eclipse's commencement, may serve as the indication that the F_2-layer is not simple : the intensity of the F_2-layer's ionization is connected with the magnitude $\chi(t)$ by a more complex dependence than $\cos\chi(t)$, although it is being determined by the daily course of Sun's zenithal angle.

It may also be noted that small fluctuations exist in the course of critical frequencies of both layers during the eclipse. In the F_2 - layer the f_o variation relatively to a smoothed curve constituted about ± 0.15mc/s, and in the E-layer — near ± 0.1 mc/s. This may have been caused by errors in critical frequency computation, as well as by a certain increase in solar activity during that period : According to IZMIRAN data, there was registered an increased level of solar radio emission within the 3 cm — 1.5 m. wave band on the day of the eclipse. Numerous sunspots, and an increased intensity of a series of coronal lines were also observed.

There was observed during the hours 08 00 — 11 00 of the day of eclipse a lamination in the E-layer. Between the hours 08 45 and 11 00, the type-ℓ of the E_s layer was observed, later passing to type-C, which was present till the end of observations. The critical frequencies of both types of E_s- layer were close to f_oE

in the course of the day, and did not exceed them by more than 0.2 — 0.4 mc.s. At the end of the eclipse, the critical frequencies $f_o E$ coincided with the median, while the $f_o F2$ frequencies, though distinct from the median, followed up the general dependence, characteristic of that time of the day and of the year. Analyzed were also the peculiarities of variation in time h'(t) of the heights at fixed frequencies $f = 10$ and 11 mc/s., with the aid of h'f — characteristics related to the period of eclipse. In the first case, the h'(t) variations during the hours of eclipse revealed the same trend as in control days, but the corresponding magnitudes h' increased as an average by 50 km in the eclipse process.

At the frequency of 11 mc/s, the dependence h'(t) had a more typical form, characteristic for the effect of eclipse in the ionosphere, the effective heights began to increase directly after the commencement of eclipse, and having reached the maximum at the time of maximum phase, gradually decreased to values during control days, simultaneously with the end of eclipse. At the time of maximum phase, the magnitude h' exceeded as an average the median values by 100 km during the same hours. No particular anomalies in the h' (t) course, pointing to a substabtial deformation of F_2 - layer were observed during the eclipse.

Processing of the Results of Observations.

The high-frequency characteristics h'f and the time course of magnitudes $f_o E$ and $f_o F2$ during the control and eclipse days were utilized for the estimate of the effective recombination coefficients and of the ionization intensity in the E and F2 - layers. The true distribution of the electron concentration N_e (h) was only found for the F_2 - layer by the method proposed in [5], using the h'f-characteristics. Dependences N_e (t) for $h = 250$ and 300 km, were plotted during eclipse time. Then the magnitudes dN_e/dt, entering the ionization balance equation, were determined with their aid.

The computation of the magnitude $\alpha_{eff} F2$ was effected by the method of contiguous points, taking into account the dependence N_e (t) for h = 250 and 300 km, and also by the method when in one case the ionization balance equation was composed for a specific moment during the eclipse, and in the other — for the variations of median values of electron concentration in the F_2-layer maximum. Inasmuch as no significant oscillations of magnitudes $h'F_2$ and $h_p F2$ were observed during the eclipse as well as control days near midday hours, and values h_p were near 300 km. the N_e (t) variations at that altitude were related to the F_2-layer maximum.

As a result, the average arithmetic value of $\alpha_{eff} F_2$ was computed according to its 10 separate magnitudes, and found to be $\sim 2.0 \cdot 10^{-10} cm^3 sec^{-1}$. Accordingly, the average arithmetic value of ionization intensity J_o in the F2-layer maximum constituted about 2300 $el/cm^3 sec$. The computation of α_{eff} E and J_o for the E-layer was effected with the help of curves characterizing the f_oE critical frequencies' variations in the day of eclipse and in control days. At the same time, it was assumed that the height of the E-layer maximum did not vary during the period of eclipse. In the aggregate, the following average values were found :

$$_{eff}E \simeq 0.25 \cdot 10^{-8} cm^3 sec^{-1},$$

$$J_o \simeq 150 \ el/cm^3 sec.$$

Taking into account the results of measurements of α_{eff} and J_o during the periods of preceding eclipses, brought out in [6], one may conclude, that by order of magnitudes, our data agree well with them. At computation of the covering functions, entering the ionization balance equation, it was admitted, that the radiation, ionizing the ionosphere, was uniformly distributed over the disk of the Sun.

Thus, taking into account the circumstances of the effect in the ionosphere (particularly in the F_2-region) of the eclipse, and the fact that at α_{eff} and J_o computations, their values were considered constant during the total period of eclipse, and they did not differ from the corresponding magnitudes in the control days, the data obtained by us are to be considered only as the most probable.

ECLIPSE EFFECTS IN THE IONOSPHERE ON 15 Feb.1961

The solar eclipse of 15 February 1961 was partial in the Gor'kiy region, with a 0.94 maximum phase on the ground. The eclipse began at 10 20 hours and ended at 12 46 hours. The maximum phase began at about 11 33 hours. During that period, the ionosphere observations were conducted every 5 minutes. Check observations were conducted every 15 minutes between the 9th and the 24th February, so as to clarify the degree of the effect of eclipse in the E and F2 - layers.

The comparison of the course of the critical frequencies f_oE and f_oF2 during the eclipse hours, with that of corresponding median values related to control days, has detected a distinct decrease, more particularly in the E-layer. However, the eclipse phenomenon had a different course in the E and the F_2- layer.

The greatest decrease in electron concentration in the E-layer maximum, and of the values f_{min} characterizing the degree of radiowave absorption in the D-layer, have practically coincided with the moment of the greatest eclipse phase, while the analogus phenomenon for f_oF2 took place significantly later (near 2 hours). (See Fig. 2, on top). The relative decrease in f_oE and f_oF2 values respectively constituted in the two cases $\sim$ 35 and 17 percent, and for the magnitudes f_{min} — near 30 percent in comparison with the median values. It may be concluded from the graph that during the hours of eclipse, the median curve f_oF2 is not smooth. This is explained by the fact, that the course of f_oF2 during control days for the same period of time was very irregular. Thus, for instance, separate values of f_oF_2 reached nearly 9.0 mc/s in daytime on February 14, while on the 16th they did not exceed for the same hours $\sim$ 7.7 mc/s. There is a basis to assume that similar anomalies in the course of f_oF_2 during the control days were linked with solar activity, which, as noted in [7] , may exert a different effect on E and F2-layers' ionization.

The anomalies in the state of the F_2-layer were also revealed by the fact, that the magnitudes h' F2 and h_p F2, determined with the help of h'f- characteristics for the day of eclipse and for the control days, were subject to substantial variations.

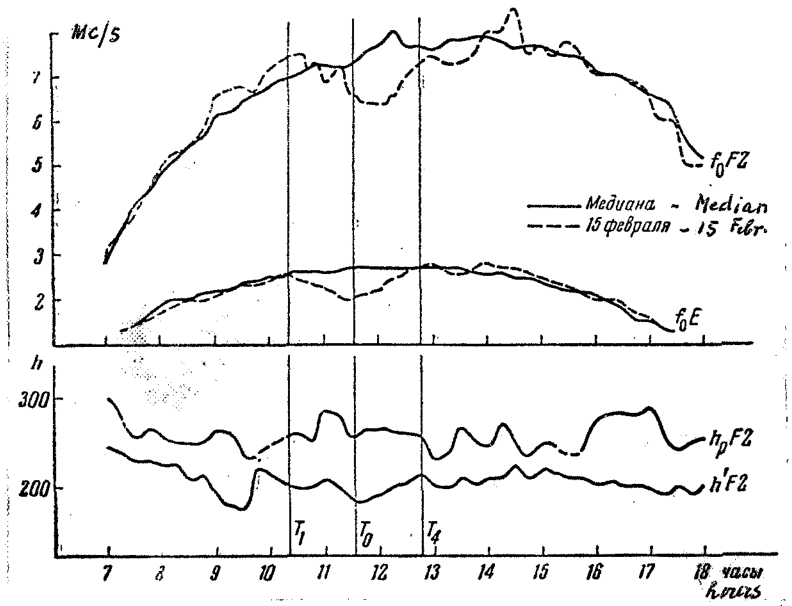

Fig. 2

Brought out in Fig. 2 are the dependences for the day of eclipse of minimum effective heights h' F_2 and values h_p F_2, characterizing the altitude of the F_2-layer maximum in the assumption that the electron concentration $N_e(h)$ was distributed in it according to the parabolic law. Upon reviewing these dependences, it ought to be assumed, that the shape of the F2-layer in daytime did not remain constant. It is pertinent to note that the dependences h' F2 and h_p F_2 had an analogus character during the control days.

Prior to eclipse commencement, laminations took place between 0800 and 10 00 hours in the E-region, while during the period of eclipse type l- E_s-layer was observed, partly shielding the E-layer. At the beginning of the eclipse, its critical frequencies were 2.1 mc/s gradually descending to 1.6 mc/s at the moment of the maximum phase.

That type of E_s- layer disappeared after the end of the eclipse. The type-h E_s- layer' presence was revealed in the ionograms from 1415 to 1530 hours with a maximum frequency of 2.7 mc/s. Laminations and sporadic type l and C layers were simultaneously observed with the former at separate moments.

Lamination was also observed in the lower part of the F_2 - layer between 08 20 and 09 35 hours. It was conditioned by the presence within it of nonhomogeneities in the electron concentration. At 09 55 hours a perturbation was noted in its upper part in the electron concentration distribution $N_e(h)$ which was shifted in time to the lower part of the layer. By 00 15 hours it could have been interpreted as the L- condition.

During the hours close to the commencement and the end of the eclipse, the F_1 -layer was weakly represented. However its critical frequencies were clearly expressed during its maximum phase, and diminished to 2.5 mc/s. The minimum effective height of the F_1-layer descended at the same time to 170 km.

Comparing the results of ionosphere investigations during the period of the given eclipse with similar observations of 2 December 1956, one may conclude that though both eclipses took place in winter, at a more or less the same time, their influence on E and F_2 - layers were expressed differently. This may possibly stem from the fact, that in December 1956 the F_2-layer followed to a greater degree the laws of a simple layer than in February 1961. Besides, it is not excluded that this has been linked with the difference in solar activity, and also in geometry of the eclipse in the ionosphere. One may hope that the multilateral analysis of the results of the February 15 eclipse, obtained by the worldwide network of ionospheric stations and expeditions, together with the recourse to data on solar activity, will permit to describe sufficiently completely the physical aspect of phenomenas in the ionosphere caused by the present eclipse.

Let us note in conclusion, that disregarding separate details in the state of the ionosphere on 15 February 1961, the effects of the eclipse upon the E and F_2- layers above Gor'kiy reveal common peculiarities with those described in [8].

The authors express their gratitude to N. A. Mityakov and V. P. Petukhov for their assistance in organizing eclipse observations, and in the preparation of graphs, and also to G. M. Arte-m'yeva, having effected the extrapolation of the data on optical darkening upon the altitudes in the ionosphere.

**** THE END ****

R E F E R E N C E S

1. H. N. CONES. J. Res. Nat. Bur.Standards, 46, 113, 1951
2. G. V. VASIL'YEV, K. N. VASIL'YEV, L. P. GONCHAROV. Geomagn. i Aeron. Tom I., No.1, 120-7, 1961
3. Rukovodstvo po vertikal'nomu zondirovaniyu ionosfery. Izd-vo A. N. SSSR, 1957.
4. Astronomicheskiy yezhegodnik na 1956 (Astron. Yearbook 1956)
5. W. J. G. BEYNON, J. O. THOMAS, J. Atm. & Terr.Phys.,9, 184, 1956
6. Ya. L. AL'PERT, V. L. GINZBURG, E. L. FEYNBERG, Pasprostraneniye radiovoln, Gostekhizdat, M., 1953
7. N. M. BOYENKOVA. Polnyye solnechnyye zatmeniya 25.fevralya 1952 g. i 30 iyunya 1954 g. Izd. A.N.SSSR 1958
8. K. N. VASIL'YEV, A. S. VELESHIN, A. R. KOSENKOV, Geomagntism i Aeronomiya, Tom I, No. 2, 277, 1961

Gor'kiy State University in the name of
N. I. Lobachevskiy
Radiophysical Scientific Research Institute

Entered on 6 Sept.1961

Translated by ANDRE L. BRICHANT
for the
NATIONAL AERONAUTICS AND SPACE ADMINISTR'N